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Seeding and transplanting equipment for rice production during last four decades - A Review

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ABSTRACT

The review paper includes the rice sowing and transplanting equipment's developed during four decades for reduction in cost of cultivation and quality of operation The line sowing of paddy not only requires less seeds but also facilitate regulated application of fertilizer near root zone. Besides, it helps control of weeds through use of mechanical weeder. In direct seeding, dry paddy seeds are sown in line with one, two and three row manual seed drill, three row animal drawn seed drill, self-propelled hill seeder, power tiller and tractor drawn seed drill for upland conditions for plain terrain whereas manual, bullock drawn and power tiller drawn seed drills are suitable for hilly terrain. The traditional practice of nursery raising (800 m^2) for rice crop requires about 75 kg of paddy seeds and about 2.5 to 3.0 times higher area as compared to improved method of mat type nursery raising. The traditional practice needs more labour and water. The cost of raising mat type nursery for transplanting in one-hectare area is 49% higher as compared to improved nursery for raising seedlings on plastic mats using frames. Transplanting method is more popular among farmers in most areas due to higher yield and less weed growth as compared to direct seeded rice. Prototype feasibility testing of improved rice sowing and transplanting equipment's were assessed during multi-locational trials and later such units were covered under frontline demonstrations through centres of AICRP on Farm Implements and Machinery across the country. The trainings for raising mat type nursery and using transplanters helped in large scale popularization. The custom hiring of riding type transplanters was found successful and other centres like Karnataka, Odisha, Punjab and Haryana have made efforts for custom hiring of riding type transplanters. The manual rice transplanter, paddy drum seeder self-propelled transplanting units gave effective field capacity of 0.02 ha/h, 0.12 ha/h and 0.10-0.15 ha/h, respectively.

1. Introduction

Asian countries occupy 89% of the world total paddy area, and producing 90% of the total rice production. India is the world's second largest producer of rice and brown rice, accounting for 20% of all world rice production and has the largest area under rice cultivation, as it is one of the principal and dominant food crop of more than 60 per cent population in the country. The total rice cropped area is 161.5 million hectares in the world. In India, rice is grown on an area of 43.5 m ha with a total production of 105.5 mt and productivity of 2.4 t/ha. The country has 49.5% irrigated rice area, 13.5% upland rice area and 32.4% rainfed rice are out of total rice area in the country. In the north eastern states rice is the main crop. The rice area in Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura are 2176, 123, 166, 104, 51, 164, 15 and 212 million hectares, respectively. Shortage of labor for manual rice planting can cause the failure of scheduled transplanting.

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed. In transplanted rice, 3000-5000 lit of water is required to produce 1 kg of rice. Rice is grown either by direct

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seeding i.e. broadcasting, drilling in dry soil, sowing in wet soil or by transplanting. Rain fed rice is grown in 16 states namely Chhattisgarh, Bihar, Odisha, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Jharkhand, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Rajasthan, Punjab and Uttarakhand. The climate ranges from arid, semiarid to humid in these states. Three enhancing water productivity technologies for rainfed rice cultivation viz., broadcast, broadcasted biasi and direct row seeding of rice are followed by farmers. Broadcasting is the popular method of rice in the prevailing situation to combat erratic rains. In case of broadcasting, weeding is problem because it only permits hand weeding or chemical weed control method. Broadcasted biasi method of rice cultivation is followed in Chhattisgarh and Odisha. Basically *biasi* is an operation carried out by the farmers using indigenous plough in Broadcasted rice in standing water after the plants attain a height of 140 to 150 mm (35-40 days).

The mechanical rice transplanters are classified on the basis of nursery used i.e. machine using wash root seedlings and machine using mat type seedlings. Mechanical transplanters require 3 man days/ha than manual hand transplanting of 33 man days/ha. The mechanical transplanters use ensures less weed growth and higher yields than any other methods of dry or wet rice seeding or manual hand transplanting. In rice farming, a worker has to bend over 2.5 lakh times for transplanting rice seedlings in one-hectare area which causes a lot of drudgery as well as occupational health problems. The rice transplanter ensures low cost of production and higher rice yield. They can also save the seeds, about 60 percent.

D*irect seeding in dry soil*

Direct seeded rice helps farmers to earn more carbon credits than transplanted rice by mitigating methane emission and saves water and reduces labour requirement. Dry direct seeded rice is mostly practiced in rainfed uplands, lowland and flood prone areas in the country. In Punjab, Haryana, Tamil Nadu and Andhra Pradesh, farmers have adopted seed drill for line sowing of paddy under dry soil and sowing mechanization ranges from 10 -100%. Tractor drawn seed drill having inclined plate seed metering mechanism (PAU) required seed rate 25-30 kg/ha which is low in comparison to seed rate of fluted roller metering seed drill as 75-80 kg/ha. In direct seeded rice there is more weed competition (Din *et al.*, 2014). Planter cum herbicide applicator was developed by CAE, Baptala centre of AICRP on FIM, for direct sowing of paddy. Its field capacity and field efficiency were 0.4 ha/h and 90% in clay loam and black cotton soils at 15-20% (db) moisture content. The cost of operation of planter cum herbicide applicator was Rs. 1200/ha (Anonymous, 2018).

OUAT Bhubaneswar centre of AICRP on FIM evaluated tractor operated 9 row multi crop planters for dry seeding of rice. The planter having vertical roller metering mechanism and individual pick up chamber for both seeds and fertilizer gave effective field capacity of 0.4 ha/h. with a field efficiency of 69%. The cost operation was Rs 1740/ha and labour requirement was 5 man-h/ha. It resulted in saving of Rs 3380/ha and Rs 7260/ha as compared to self-propelled transplanter and manual transplanting (Mehta, 2017).

TNAU Coimbatore centre of AICRP on FIM developed and evaluated tractor mounted direct rice seeder. The overall dimension of unit row was 2350 x 110 x 110 mm. It consisted of cut feed type metering mechanism which was fitted with reversible shovel type furrow openers. The equipment gave field capacity of 0.68 ha/h with field efficiency of 75%. The width of coverage and seed rate were 1830 mm and 45kg/ha respectively. It saved 72% in labour and operating time and 64% in cost of operation than manual broadcasting method (Singh *et al.*, 1997).

Direct seeding in wet soil

Manual paddy drum seeder has become popular in Andhra Pradesh, Tamil Nadu, Kerela, Odisha, West Bengal, Assam, Puducherry and North-eastern regions. The manual 4-rows and 6-rows drum seeders being light in weight can be operated easily by female farm women in low land area. Eight row plastic drum seeder developed by TNAU Coimbatore is lighter in weight and easier to pull in puddle fields. CIAE- IEP Centre, Coimbatore commercialized this equipment in the state of Tamil, Nadu. It has a lugged ground wheel and two skids. Use of this device results in 16% increase in yield compared to conventional method. CIAE-IEP Centre, Coimbatore has developed a 12- row riding type self-propelled plastic moulded drum seeder for paddy in 2005-06. Self-propelled 8-rows paddy drum seeder has been developed by CRRI Cuttack and OUAT, Bhubaneswar (FIM) in the year 2012-13. Its field capacity was 0.235 ha/h (Din, *et al.*, 2014).

IIT kharagpur centre of AICRP on FIM conducted field trails of manual paddy drum seeder. The effective field capacity varied 0.10-0.14 ha/h. Labour requirement was 15-20 man-h/ha. It saved 98% in labour requirement than hand transplanted method (including nursery rising).

AAU Jorhat centre of AICRP on FIM conducted feasibility testing of 4 different types of manually operated paddy drum seeder (24, 20, 12 and 8 kg). The adoption of mechanical drum seeders resulted in time saving of 78-95% over manual line showing method. The field capacity varied 0.139-0.283 ha/h. The grain yield also increased by 10.36% than manual hand transplanting method. NEH Barapani modified 4 row paddy drum seeder. The effective field capacity varied 0.04-0.06 ha/h. The cost of operations was Rs 500/ha than Rs 1000/ha in manual transplanting. The labour requirement was 30-40 man-h/ha than 300-400 man-h/ha in manual hand transplanting method (Pandey, 2006).

Paddy drum seeders were feasibility tested at JNKVV Jabalpur, CSKHPKV Palampur and AAU Jorhat in total 22 ha. The effective field capacity and field efficiency was 74% saving in cost of operation were 0.18 ha/h and Rs 6000-7000/ha at JNKVV Jabalpur. The 4 row and 8 row paddy drum seeders gave effective field capacity of 0.11 ha/h and 0.23 ha/h, respectively with field efficiency of 65-70% at HPKV Palampur. The labour requirement were 10 and 5 man-h/ha for 4 row and 8 row units. Numbers of hills were 42-45 and 45 - 48 /m^2 (Mehta, 2015).

SHAUTS Allahabad centre of AICRP on FIM conducted feasibility testing of manual paddy drum seeder. The working width effective field capacity and field efficiency were 1600 mm, 0.083 ha/h and 73% respectively. The cost of operation of seeder was Rs. 700/ha. The saving in cost of operation and time was 90% and 77% respectively (Mehta, 2017).

OUAT Bhubaneswar centre of AICRP on FIM developed and tested self-propelled 8 row pre terminated rice seeder. The unit was equipped with 3kw diesel engine as prime mover. It was provided with float made of plastic fiber of size 1100x1700mm. The overall dimension of unit was 2410x2297x1200m and weight of rice seeder was 250kg. The unit gave effective field capacity of 0.25 ha/h and field efficiency of 72%. The cost of operation was Rs 900/ha and labour requirement was 8 Man-h/ha. It saved 25% in cost of operation and time as completed to manual 8 row rice drum seeder (Mehta, 2019)

2. Transplanting

In India, 44 per cent of rice area (19.6 million ha) is under transplanting in irrigated lowlands and hand transplating using root wash seedlings of rice is mostly practiced in India. It is time and labour consuming besides being an arduous operation. It required about 238 man hours for per hectare for manual transplanting the workers change their posture very frequently. This may cause suffering from muscular skeletal disorder.

In order to reduce drudgery and mechanize the transplanting operation, mechanical rice transplanters have been introduced. Transplanters can also be classified on the basis of the type of nursery required by them e.g. root washed seedlings type and soil bearing seedlings type. In the root washed seedlings type transplanter, the nursery is raised in the conventional way on moist or puddle soil. The root washed seedling based mechanical rice transplanter were not found suitable because of high labour requirement with this machine and no net labour saving over the manual transplanting. Only mat-type nursery based transplanters have scope for adoption. Efforts have been made to mechanize the process of transplanting right from the fifties both for manual, self-propelled and tractor drawn type of transplanters. Different designs were tested and modified for adoption using the mat type nursery.

Manual transplanter is useful machine for marginal and small farmers because of its higher capacity as compared to hand transplanting. The manual rice transplanter provides average effective field capacity of 0.38 ha/day as compared to effective field capacity of 0.04 ha/day in hand transplanted rice method. The first patent of manually operated rice transplanter was taken in Japan in 1898 and thereafter it took nearly six decades to bring a workable machine in market. Chinese design was improved by IRRI Philippines and they developed 5- row / 6 - row models. The IRRI 6-row manual rice transplanter formed the basis for many versions of manual transplanters developed by many institutes in the country. Four row manually operated rice transplanter using root washed seedlings developed by national Institute of Agricultural Engineering, U.K. was first tested at CRRI Cuttack in 1966. The planting efficiency was 70-80% and labour requirement was 220-245 man-h/ha (Das, 2003).

CRRI developed manually operated 2-row and 4-row rice transplanters which were suitable for transplanting of 20-22 days old mat type rice seedlings in rows in puddle soils (Anon.,1990-91). OUAT Bhubaneswar centre of AICRP on ESA developed three row rice transplanter using mat type seedlings. These three models can be operated easily by farm women at plain terrain. Being light in weight, these manual rice transplanters can be used for hilly terrain also. Four row rice transplanter saves about 30-40% labour requirement and 40% cost in transplanting operation (Din *et al.*, 2014).

PAU Ludhiana centre of AICRP on FIM developed & tested 6 row manually operated rice transplanter. The overall dimensions of unit were 1460 x 1330 x 530 mm and its weight was 20 kg. Fixed opening type fingers actuated by hand operated labour mechanism were used for 200 mm row spacing in the unit. The effective field capacity varied 0.04-0.05 ha/h and field efficiency of 55-60% respectively.

The width coverage operating speed and plants per hill were 1200 mm, 0.5-0.7 km/h & -, respectively. It saved % labour and operating time &% in cost of operation. TNAU Coimbatore centre of AICRP on FIM developed manually operated 5 row rice transplanter. Its overall dimensions were 1200 x 1160 x 570 mm. The unit of 25 kg weight had raw type fingers actuated by hand operated lever mechanism. The five rows unit gave field capacity of 0.012 ha/h and labour requirement was 150 man-h/ha. The missing and floating hills were 1-4% and 1% respectively. The width of coverage and seedlings has fill were 1000 mm and 3-5. It saved 65% labour and operating time and equipment also saved 45% in cost of operation (Singh *et al.*, 1997).

HPKV palampur conducted feasibility testing of 6 row manual rice transplanter. The effective field capacity and field efficiency were 0.033 ha/h and 56% respectively. The labour requirement was 61 man-h/ha. Saving in the cost of transplanting including nursery raising was 68% as compared to hand transplanting with root washed seedlings (Pandey, 2006).

CAEPH Ranipool centre evaluated manual two row rice transplanter (weight 20 kg) for root washed seedlings at 250mm row spacing. The effective field capacity varied 0.046- 0.056 ha/h and field efficiency of 62.01-67.4%. the missing hills ranged 5-11% and seedlings/hill were 2-4. The hill spacing was 184-213mm. it saved 14-28% in transplanting than manual hand transplanting (Mehta, 2017).

The large scale frontline demonstrations of 8 row self-propelled rice transplanters were carried out at farmer's fields in a total area of 96 ha during 2004-2013 in different villages of Khurda, Puri, Balasore, Cuttack, Bhadrak and Sonepur districts of Odisha state. The machine was demonstrated at Hirakud command area during 2008-12 and an area of 68 ha was covered. The machine was widely accepted by the farmers of Odisha state as more than 609 transplanters were sold during 2013-14. Presently, about one thousand self-propelled rice transplanters are in use in Odisha state. The state govt. provided subsidy up to 75% on purchase price of transplanter to the farmers (Anon., 2015).

Mechanical Rice Transplanter

A power operated transplanter of Mametora making using root wash seedlings was introduced in Japan in mid-sixties. China and Korea also made transplanter in mid-sixties. In India, transplanters using root wash seedlings were tested and manufactured during seventies but could not become successful due to difficulty in limiting the number of seedlings per hill and more labour requirement. The self-propelled transplanter (Chinese design) using mat type seedlings was tested and being adapted in India since 1995.This self-propelled rice transplanter is commercially available in India and covers 8-rows with 238 mm row spacing per pass. The unit is single wheel driven and fitted with a 2.94 kW diesel engine. The transplanting system consisted of fixed fork and knocks out lever type planting fingers. The effective field capacity and field efficiency were 1200 m^2/h and 76%, respectively. The self-propelled transplanter gave net profit of Rs. 5745/- and Rs. 7000/- per ha for use of mechanical transplanter without subsidy and with subsidy respectively over the manual transplanting in Inland Odisha. Similarly, net cost saving per ha was Rs. 9650/- and Rs. 8395/- by use of mechanical transplanters with and without subsidy respectively, in coastal Odisha. The use of self-propelled Walk behind- Yanmar, Kubota, Kukje, Class, VST Yanji and Mahindra & Mahindra etc., make Rice transplanter using mat type seedlings are commercially available in India. Farmers of Kerala, Tamil Nadu, Andhra Pradesh are using mechanical transplanters due to labour's scarcity and higher labour wages. Transplanting mechanization ranges between 10-65% whereas it is becoming popular in Odisha, Chhattisgarh and Punjab. Mechanical rice transplanter (Single wheel drive) woked well in loamy soil but it did not perform that well in clay soil due to poor traction and sinkage problem. Its transportation is difficult in hilly terrain. Six and eight row self-propelled 4- wheel riding type transplanters of Yanmar, Kubota and Class etc. make are commercially available in India. These transplanters perform well in clay soil and sinkage under field condition. In valley lands and terraces the performance of riding type rice transplanter was not found satisfactory. In case of irregular fields shapes of lands like in terraces; lot of land was left un-transplanted with the machine, which needs to be filled by hand transplanting (Din *et al.*, 2014).

A power tiller mounted eight row machine developed at ANGRAU, Hyderabad which gave filed efficiency of 0.13 ha/h & field efficiency of 68%. The equipment of 85 kg weight gave 3.1 plants/fill and missing fills of 6%. There was saving of 90% in labour 80% in operating time and 37% in cost of operation compared to conventional manual hand transplanting of root washed seedlings. PAU Ludhiana centre of AICRP on FIM developed 8 row self-profiled riding type rice transplant suitable during 1984-1990 for transplanting mat type seedlings. The unit (280 kg weight of) had fixed type planting fingers was equipped with 3.7 kW diesel engine. The overall dimensions of transplanter were 2550 x 2040 x 1350 mm. The rows spacing & width of coverage were 225 mm and 1800 mm. The unit gave effective field capacity of 0.15-0.20 ha/h and field efficiency of 55-60%. The hill to hill distance, missing hills and labour requirement were 115-170 mm, 8-15 and 35-40 man-h/ha, respectively. The machine saved

65% in labour and operating time. It saved 35-40% in cost of operation than manual hand transplanting (Singh *et al.*, 1997). The riding type self-propelled rice transplanter was evaluated which gave effective field capacity of 0.12 ha/h in black cotton soil condition at CIAE, Bhopal. The cost of transplanting was Rs 2080/ha including Rs 950 for nursery rising. The mechanized transplanting using mat type nursery was 47.8% cost effective compared to hand transplanting with root was seedlings (Rautray, 2002).

TNAU Coimbatore and KAU Tavanur centres of AICRP on FIM evaluated riding type paddy transplanter (11 kW) in an area of 199 ha. The number of seedlings/fill varied 2-3 at row spacing of 300 mm. The hill to hill spacing could b adjusted of 120,140,160,180 and 200 mm. The transplanter gave filed capacity of 0.30-0.38 ha/h. PJTSAU Hyderabad centre of AICRP on FIM developed and evaluated 4-wheel drive mini tractor mounted 8 row rice transplanter. The overall dimensions were 1150 x 1290 x 960 mm. The effective field capacity of equipment was 0.24 ha/h and field efficiency was 60%. The missing hills were 7.04%. The cost of operations was Rs 1919/ha (Mehta, 2019).

In Karnataka state, use of walk behind type paddy transplanter saved 48.03 % of cost with saving of 72.22 % of time. Whereas the use of riding type paddy transplanter saved 44.60 % of cost with saving of 83.33 % of time compared to traditional method of paddy transplanting. There is monetary benefit of Rs. 4563/ha and Rs. 4237/ha by using walk behind type transplanter and riding type paddy transplanter respectively as compared to traditional method of paddy transplanting (Anonymous, 2015).

The adoption rate of mechanical transplanter in India is low due to high initial investment, small land holdings and lack of knowledge in growing mat type nursery. They are getting popular on custom hiring mode due to their high initial cost. Imparting technical knowledge, ensuring time availability of spare parts and more custom hiring centers may be some of practical solutions for more adoption of mechanical rice transplanter in India. There is need to develop self-propelled rice transplanter using root wash seedlings for Indian Condition. There is need to promote self-propelled walking type rice transplanter for small and medium land holding rice. The riding type rice transplanter may be introduced on large size land holding on custom hiring basis (Guru *et al.*, 2018).

CRRI manual rice transplanter

Single wheel riding type rice transplanter

Four wheel drive riding type rice transplanter

- ***System of Rice Intensification (SRI) Method of Transplanting***

In SRI method, young (8-10 days old) seedlings were transplanted manually. The row to row distance and within a row plant to plant distance were 250 x 250 mm. With this spacing, there were 16 plants/m^2 in SRI method. In the conventional method, 33-40 hills were transplanted per square metre with 4-5 plants per hill. It was time and labour consuming besides being an arduous operation. Manual and mechanical commercial available rice transplanters took more seedlings. AICRP on FIM-TNAU centre modified in mechanical transplanter which planted 2-3 seedlings per hill and maintained row to row and plant to plant distance of 240 x 240 mm (Din *et al.*, 2014).

3. Conclusion

There are various proven designs for sowing, seeding and transplanting developed under AICRP on Farm Implements and Machinery during last four decades which were later manufactured by Prototype Manufacturing Centres and commercialized involving regional manufacturers to bridge the mechanization gaps across the country. The equipment's succeeded in savings of seeds, fertilizers, chemicals, water, fuel, labour, time and drudgery in addition to reduced cost of cultivation depending on power source. The transplanters use have gain momentum through custom hiring and for dry seeded rice farmers are adopting equipment for timeliness of operation. Although manual rice transplanters and paddy drum seeders were demonstrated across the country but ownership is still limited due to skill required for mat type nursery raising technique and special skill required for operation of such units.

4. References

Anonymous, 2015. Status Report on "Adoption of Self-propelled Rice Transplanters in Raichur Region of Karnataka". AICRP on FIM Centre, UAS Raichur.

Annual Report 2018-19. AICRP on FIM Centre Bapatla, Acharya NG Ranga Agricultural University, Guntur (Andhra Pradesh).

Das FC., 2003. CRRI drum seeder for sowing pre-germinated paddy seeds in puddle field. Proceedings of the International Seminar on Downsizing Technology for Rural Development, Vol (I), 139-143.

Din, M, Mehta CR, Annamalai SJK, Singh Manjeet, Behera Dabaraja and Paikray Pradeep Kumar, 2014. Road map for mechanization of rice cultivation, Central Rice Research Institute Cuttack, Policy Paper No.2, Pp. 1-4

Guru Prabhat Kumar, Chhuneja NK, Dixit A, Tiwari PS and Kumar Anjani, 2018. Mechanical planting of rice in India: status, technological gaps and future thrust *Oryza, 55(1)*, 100-106.

Mehta CR, 2015, Research Highlights 2015, Published by ICAR- Central Institute of Agricultural Engineering, Nabibagh, Bhopal. Technical Bulletin No. Bulletin No. CIAE/FIM/2015/179

Mehta CR, 2017. Four decades of salient achievement. Published by AICRP on FIM, ICAR- Central Institute of Agricultural Engineering, Nabibagh, Bhopal. Technical Bulletin No. CIAE/FIM/2017/235

Mehta CR, 2017 Research Highlights... 2017. Published by Central Institute of Agricultural Engineering, Bhopal (MP). Technical Bulletin CIAE/FIM/2017/2018,

Mehta CR, 2019. Recent farm mechanization technologies. Published by AICRP on Farm Implements and Machinery, Central Institute of Agricultural Engineering, Bhopal. Technical Bulletin No: CIAE/FIM/2019/283

Pandey MM, 2006. Research Highlights .2006. Published by AICRP on Farm Implements and Machinery, Central Institute of Agricultural Engineering, Bhopal. Technical Bulletin No: CIAE/2006/123.

Rautray SK, 2002. Self-propelled Transplanter for Mechanized Transplanting of rice – A success stories. Published by AICRP on FIM and NATP mission mode project on Rice-Wheat mechanization. Central Institute of Agricultural Engineering, Bhopal (MP). Extension Bulletin No. CIAE/FIM/2002/23

Singh G, Devnani RS, Pandey MM and Majumdar KL, 1997. Improved Farm Machinery Directory. Published by Director, Central Institute of Agricultural Engineering, Bhopal.